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THE MEAN BAROMETRIC PRESSURES ALONG THE VARIOUS CIRCLES OF LATITUDE—A RÉSUMÉ OF DATA

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Occasions sometimes arise when the meteorologist or worker in allied fields has need for the mean values of the barometric pressure along the various circles of latitude. There exist a number of compilations of such data with accompanying studies, but usually these compilations are incomplete, derived from different sources, and scattered in divers publications often unavailable to the worker not having access to an extensive meteorological library. It is therefore desirable to bring together several of the more important of these compilations so that there may be available in one place a complete set of data, so far as published, for latitudes extending from pole to pole. This is the object of the present paper.

Beginning with the North Pole, we have available, first, a set of mean monthly isobaric charts for the North Polar Regions constructed by H. Mohn (1) largely upon the basis of mercurial barometer readings made on the S.S. *Fram* during its voyage and drift with the icepack in the North Polar Seas in connection with the Norwegian Polar Expedition, 1893–96, under the leadership of Fridtjof Nansen. Table 1 shows the monthly mean barometric pressures (reduced to sea level) at the North Pole (latitude 90° N.) according to these charts. The values were obtained by the writer by interpolating [1] between the mean isobars.

TABLE 1.—*Mean barometric pressures at latitude 90° N., according to Mohn*

[Pressures are reduced to 0° C., standard gravity and sea level]

Month	Pressure	Month	Pressure
	Mm Hg		*Mm Hg*
January	760.9	July	758.4
February	762.0	August	759.6
March	760.8	September	758.0
April	763.9	October	760.7
May	762.6	November	760.6
June	758.9	December	760.9

Mohn (loc. cit.) reduced the mercurial barometer readings made every second or fourth hour in the cabin of the S.S. *Fram* to hourly readings by the use of his barograph records. From these he computed the mean monthly barometric pressures corresponding to the track of the ship for each month of the entire voyage. Table 2 shows these data in extenso, with the position of the ship at 0 hour (local meridian time) on the 1st day of each calendar month.

[1] The *tenths* place is not to be regarded as strictly accurate.

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TABLE 2.—*Mean monthly barometric pressures—Voyage of the S.S "Fram"*

[Pressures are reduced to 0° C. standard gravity and sea level]

Month and year	Position at 0 hour on 1st day of month: Lat. N.		Long. E.		Mean pressure	Month and year	Position at 0 hour on 1st day of month: Lat. N.		Long. E.		Mean pressure
	°	′	°	′	*Mm of Hg*		°	′	°	′	*Mm of Hg*
1893						1895—Con.					
August	69	41	60	20	760.0	February	83	41	103	14	770.4
September	76	25	96	35	754.5	March	83	57	101	43	768.3
October	78	56	133	09	761.8	April	84	10	99	14	764.7
November	78	07	135	05	760.0	May	84	14	93	24	758.6
December	78	41	138	39	773.1	June	84	37	83	47	755.2
1894						July	84	37	74	41	754.1
January	78	58	136	48	762.0	August	84	29	76	10	761.4
February	79	52	134	29	755.4	September	84	42	77	10	753.8
March	80	02	135	23	746.3	October	85	09	79	24	765.5
April	80	07	134	57	762.6	November	85	40	70	22	755.9
May	80	45	131	29	765.7	December	85	28	58	37	761.3
June	81	31	122	16	758.1						
July	81	33	122	49	756.4	1896					
August	81	03	126	18	761.2	January	85	21	46	19	755.4
September	81	10	125	37	758.0	February	84	51	29	36	748.9
October	81	07	122	02	756.1	March	84	07	26	20	760.4
November	82	06	112	17	761.3	April	84	19	22	54	761.9
December	82	10	110	40	750.4	May	84	11	12	08	760.1
						June	83	34	12	29	762.5
1895						July	82	57	11	57	758.4
January	83	21	102	25	762.0						

The position of the *Fram* at midnight July 31, 1896, was lat. 81°28′ N., long. 13°20′ E.

Dr. Franz Baur (2) recently published a paper in which he gave the following table (table 3) for the mean barometric pressures at sea level for several circles of latitude and the North Pole. These data are based on mean monthly isobaric charts which he constructed for the Arctic regions. By far, most of the data serving as the basis for these charts were for stations lying between latitudes 64° N. and 80° N. The data derived from the voyage of the *Fram* also were used. Wherever possible, Baur attempted to reduce the data based on short periods of record to "long-period normals." The well-known "Method of the Differences of the Corresponding Observations" was employed for this purpose, (usually) two nearby stations having long periods of record serving as the points of departure. The data given in the table for the various circles of latitude were obtained by taking the arithmetic mean of the pressures found on the isobaric charts at the intersections of each given circle with each 10° meridian (i.e., 0°, 10°, 20° to 180° E. and W. of Greenwich).

TABLE 3.—*Mean barometric pressures (mm Hg) at various circles of latitude, according to Dr. Baur*

[Pressures are reduced to 0° C., standard gravity and sea level]

Circle of latitude	January	February	March	April	May	June	July	August	September	October	November	December	Annual
90° N	760.2	760.6	763.2	765.1	765.1	760.0	757.9	759.1	759.5	761.3	761.7	762.1	761.3
80° N	759.5	760.1	762.7	764.4	763.9	759.7	758.4	758.8	758.4	760.3	760.8	761.4	760.7
75° N	758.9	759.7	761.4	763.1	762.4	759.3	758.6	758.6	757.4	758.0	759.2	760.1	759.7
70° N	759.3	760.4	761.0	761.7	760.9	758.5	757.8	758.1	757.4	758.0	758.6	759.0	759.2

In table 4 are shown the mean barometric pressures (reduced to sea level) for several months and the year for various circles of latitude according to the different authorities indicated at the heads of the columns by the symbols (T), (S), (K), (F), and (M), respectively. The authorities which these symbols represent and the sources from which they derived their data respectively are: (T), Teisserenc de Bort (**3**)—mean isobaric charts constructed by himself; (S), Spitaler (**4**)—mean isobaric charts given by Hann (**5**) in Berghaus' Physikalischer Atlas; (K), Kaiser (**6**)—mean annual isobaric chart given by Hann (loc. cit.); (F), Ferrel (**7**)—mean isobaric charts constructed personally; and (M), Meinardus (**8**)—results of barometric pressure observations made by various antarctic expeditions and by various observatories in high southern latitudes during the international meteorological cooperation of 1901–04 (**9**).

TABLE 4.—*Mean barometric pressures (mm Hg) reduced to sea level for various circles of latitude according to indicated authorities: (T), (S), (K), (F), (M)*

[Barometric pressures throughout corrected to 0°C. and standard gravity]

Latitude	January	January	March	July	July	October	Year	Year
	(T)	(S)	(T)	(T)	(S)	(T)	(K)	(F)
90° N							761.2	
85							761.1	
80		757.7			758.8		760.6	760.5
75		758.3			758.2		760.2	760.0
70		760.4			757.6		759.8	758.6
65		761.7			757.4		759.8	758.2
60	759.9	761.2	760.3	758.3	757.5	758.3	759.4	758.7
55	761.8	760.9	759.2	758.6	757.9	758.9	759.7	759.7
50	762.4	762.3	760.9	759.2	758.7	760.8	760.5	760.7
45	763.4	762.7	761.9	760.0	759.4	762.5	761.6	761.5
40	764.5	763.8	762.9	760.4	759.8	763.7	762.2	762.0
35	765.6	764.7	763.3	760.1	759.6	763.9	762.2	762.4
30	765.3	764.9	762.7	759.6	759.2	762.6	761.6	761.7
25	763.8	764.0	761.9	758.6	758.5	760.9	760.4	760.4
20	761.5	762.6	760.6	757.9	758.0	759.7	759.6	759.2
15	759.5	760.9	759.3	757.2	757.9	758.6	759.2	758.3
10	758.4	759.5	758.6	757.3	758.3	757.8	758.9	757.9
5 N	757.9	758.7	758.0	757.9	758.9	758.0	758.8	758.0
0	757.7	758.2	757.2	758.6	759.4	758.4	758.8	758.0
5 S	757.6	758.0	757.6	759.6	760.1	759.0	759.0	758.3
10	758.3	757.8	757.8	760.8	760.9	760.1	759.4	759.1
15	758.4	757.8	758.2	762.2	761.9	761.4	760.0	760.2
20	759.0	758.5	759.6	763.3	763.6	762.0	760.8	761.7
25	759.7	759.8	760.6	764.8	764.8	763.6	761.5	763.2
30	760.0	761.4	762.0	764.8	765.2	764.0	762.0	763.5
35	761.2	762.4	762.6	963.6	764.0	763.1	761.9	762.4
40	761.9	761.8	760.7	761.1	760.5	760.8	761.0	760.5
45	757.1	758.8	758.5	757.9	756.8	758.0	758.1	757.3
50 S	751.0	753.6	755.3	753.1	752.7	753.9	752.4	753.2
	(M)			(M)			(M)	
50 S		752.9			753.8			753.3
55		747.1			747.0			746.9
60		742.3			741.3			741.7
65		742.4			741.2			741.2
70		743.2			742.0			741.9
75		743.7			742.4			742.6
80		744.1			742.7			743.1
85		744.4			743.2			743.3
90° S		744.5			743.4			743.4

It will be noted that the data for January, July, and the year have been derived from two sources in each case. The arrangement of the values in parallel columns makes possible a ready intercomparison. Spitaler (loc. cit.) has given a similar arrangement of data wherein he presents the mean pressures (reduced to sea level) for January and July as deduced by Ferrel (**7**), Teisserenc de Bort (**3**), Baschin (**10**), and Spitaler (**4**). From these four sets of data he computes composite means for the circles of latitude. These results are not reproduced here.

In addition to the compilation of pressures which have already been referred to, mention may also be made of those by de Tillo (**11**) and Kleiber (**12**).

We add, in table 5, the mean monthly pressures (reduced to sea level) obtained at Little America, Antarctica, latitude 78°34'S., longitude 163°48' W., during the First Byrd Antarctic Expedition. These data were kindly made available to the writer by Mr. W. C. Haines (**13**), meteorologist with that expedition.

TABLE 5.—*Mean monthly barometric pressures (reduced to sea level) at Little America, Antarctica (lat. 78°34'S, long. 163°48'W)*

Year and month	Pressure	Year and month	Pressure
1929	*(mm Hg)*	1929	*(mm Hg)*
January	747.8	August	738.9
February	741.9	September	735.6
March	741.2	October	733.3
April	743.2	November	746.5
May	734.6	December	751.8
June	744.2	1930	
July	735.3	January	743.0

It is instructive to compare for any given circle of latitude the mean pressures reduced to sea level as already presented with the actual pressures averaged over the varying surface elevations above sea level for the same circle. Table 6, taken from Spitaler (**4**), shows the mean *actual* heights of the barometer (barometric pressure *not* reduced to sea level but corrected to 0° C. and standard gravity) for the various circles of latitude. It should be obvious that data of the type given in this table rather than those of the type previously given may serve as a basis in the study of the mean advective movement of the atmosphere between the various latitudinal zones from season to season.[2]

TABLE 6.—*Mean actual barometric pressures (averaged over the varying surface elevations above sea level) for the various circles of latitude, according to Spitaler*

Circles of latitude	January	July	Circles of latitude	January	July
	mm Hg	*mm Hg*		*mm Hg*	*mm Hg*
80° N	717.1	722.9	10° N	747.8	746.7
75° N	729.9	733.0	5° N	749.9	750.1
70° N	724.9	726.2	0°	747.2	748.4
65° N	729.2	729.1	5° S	741.8	743.8
60° N	732.0	732.5	10° S	747.3	750.2
55° N	737.4	737.6	15° S	740.5	744.2
50° N	731.7	732.4	20° S	744.4	749.0
45° N	731.4	732.3	25° S	743.0	747.2
40° N	724.3	724.8	30° S	748.6	751.7
35° N	705.7	706.4	35° S	753.8	755.1
30° N	726.0	723.4	40° S	760.7	759.4
25° N	746.1	741.8	45° S	756.4	754.3
20° N	746.3	742.5	50° S	753.1	752.2
15° N	754.0	751.2			

Table 7-A, from Spitaler (loc. cit.), shows the mean *actual* pressures (i.e. *not* reduced to sea level but corrected to 0° C. and standard gravity) averaged over zones girdling the earth and having a width of 10° of latitude. It is obvious that if we take into consideration the areas of the respective zones we can compute from the data given in table 7-A close approximations to the masses of

[2] The erroneousness of using pressures reduced to sea level rather than actual pressures in the study of the advective movement of air over the globe has already been pointed out by Angot. See Annuaire de la Société Météorologique de France, T. 35, 1887.

air lying over each of the zones, and thus make available numerical values from which we can readily compute the net advective exchange of air across the boundaries of each zone between midwinter and midsummer. Table 7-B, from Spitaler also, shows the (equivalent) masses of air lying over the various zones, the data being expressed in cubic kilometers of mercury. To convert these data to units of mass, the relation: 1 km^3 mercury $= 13.6 \times 10^{12}$ kg mass, may be used.

TABLE 7.—*A. Mean actual pressures (mm Hg) averaged over 10° zones. B. Mean masses of air*[1] *(expressed in km^3 mercury) lying over 10° zones*

Latitudinal limits of zones	A		B		
	January	July	January	July	Difference, January–July
80° to 70° N	726.08	729.05	8,343.0	8,377.0	−34.0
70° to 60° N	729.18	729.56	13,681.3	13,688.4	−7.1
60° to 50° N	734.63	735.03	18,707.0	18,717.1	−10.1
50° to 40° N	729.54	730.28	22,901.6	22,925.3	−23.7
40° to 30° N	715.42	715.20	26,017.1	26,009.4	7.7
30° to 20° N	741.37	737.55	29,829.3	29,675.7	153.6
20° to 10° N	750.53	747.93	32,184.6	32,073.1	111.5
10° to 0° N	748.72	748.84	33,113.1	33,118.5	−5.4
0° to 10° S	744.53	746.55	32,927.7	33,016.9	−89.2
10° to 20° S	743.18	746.90	31,870.0	32,028.6	−158.6
20° to 30° S	744.72	748.73	29,964.0	30,126.0	−162.0
30° to 40° S	754.03	755.20	27,421.3	27,463.8	−42.5
40° to 50° S	756.82	755.22	23,757.9	23,707.8	50.1

[1] Table 7-B is obtained by converting the values given in Table 7-A to km of Hg and multiplying the results thus obtained by the corresponding areas of the 10° zones expressed in km^2. The areas of the 10° zones were determined on the basis of the assumption that the earth is a sphere of radius 6,366.7 km. Table 7-B thus does not represent precisely the mean actual masses of air lying over the zones, divided by the density of mercury, i.e., the volumes of mercury whose masses are equal to the actual masses of air lying over the zones, because the joint effect of the variations of gravity, latitudinally and vertically, has been omitted in computing the data. Thus analytically, table 7-B is given by the expression $A \times B_o$, whereas the volume of mercury whose mass is equal to the mass of air lying over the zone is given by the expression $A \times B_o \times g_s/g_m$, where A=area of zone (km^2); B_o=mean height (km) of mercury in the barometer at the surface of the zone, when reduced to standard temperature (0° C.) and standard gravity; g_s=standard gravity=980.665 cm/sec^2; and

$$\frac{1}{g_m} \equiv \frac{-\int_{B_o}^{0} \frac{dB}{g}}{B_o},$$

in which g=value of gravity in the free air corresponding to the height above the surface of the zone where the barometer (reduced to standard conditions of temperature and gravity) is B in general, conditions being assumed average for the zone. Calculation shows g_m to correspond to the value of gravity at about 7,500 m elevation above sea level. Hence for the zone 0°–10°, $g_s/g_m = 1.0050$, and for the zone 70°–80°, $g_s/g_m = 1.0001$, approximately. Also, if the earth had been considered as a spheroid instead of a sphere, slightly different results would have been obtained for the areas of the zones. See, for example, p. 142, Smithsonian Geographical Tables, Smithsonian Institution, Washington, D.C., 1906.

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HEAVY RAINFALL IN GEORGIA

By George W. Mindling

[Weather Bureau, Atlanta, Ga., Sept. 15, 1933]

The St. George record.—Georgia lies within a region that is remarkable for its excessive rains. The greatest 24-hour rainfall on record in the State is 18 inches at St. George on August 28–29, 1911. This record when made had been equaled once in Texas and exceeded once in Louisiana. At the present it has been surpassed three times in Texas, twice in Louisiana, and once each in Alabama, Florida, and North Carolina. The greatest of these was 23.22 inches at New Smyrna, Fla., October 9–10, 1924.

The St. George record is more than double that in connection with any outstanding flood of the northern part of the United States, including that of Johnstown, Pa., in May 1889; the Great Miami River flood of March 1913 at Dayton, Ohio; and the Vermont flood of November 1927.

Greatest 24-hour rainfall, by States.—Rainfall of 10 inches or more within 24 hours has never been measured in several of the Northern States, and, in some of the Rocky Mountain States not even as much as 5 inches.